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# Proficient routing by adroit algorithm in 5G-Cloud-VMesh network

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## Abstract

5G-Cloud-VMesh network (5CVN) is nascent as an economical alternative for building federated and community networks. In 5G milieu, the Aggregator Node B (ANB) is the base station with enhanced computing capabilities and storage space. In this paper, an integration of 5G-cloud-VMesh network is initiated. In this paper, we also propose a new routing algorithm for 5CVN, dubbed as 5CVN-adroit algorithm. The proposed 5CVN-adroit algorithm chooses an optimal gateway and ANB in the network layer to route the request/response from and to the service requesters and the cloud using 5G technologies. This paper endows with the network architecture and main technical features such as interconnection, integration, and intelligence of 5CVN-adroit algorithm. The simulation study shows that the 5CVN-adroit algorithm augments the routing issues such as delay, congestion, and deployment cost and it is justified based on the packet delivery ratio, average response time, routing overhead ratio, and packet collision ratio.

**Keyword:** 5G, Vehicular network, Mesh network, Cloud, Routing, Performance

## 1 Introduction

Vehicular Ad hoc Networks (VANET) are pervasive, ubiquitous, and infrastructure-free without any centralized authority. VANET is a decentralized network where each node is proficient to forward data packets between the nodes dynamically [1–4]. In VANET, a node can be bus, tram, subway, train, or taxi. Vehicles get a broadband wireless access by using heterogeneous wireless technologies, namely IEEE 802.11, IEEE 802.16 (WMAN, WiMax), 3GPP Universal Mobile Telecommunications System (UMTS), and Long-Term Evolution. A wireless mesh network (WMN) is a multi-hop communication network in which the nodes are self-organized (i.e., without a central coordinator) [5]. VMesh is a hybrid network, which combines the features of VANET and WMN. VMesh network is the communication environment between the vehicles made up of radio nodes organized in a mesh topology. VMesh generates a loop among the moving vehicle. In the loop, we can add, update, or remove the nodes [6]. Vehicles are becoming more sophisticated with powerful on-board computing capabilities such as tons of on-board storage and short- or medium-range wireless transceiver

with no power limitations. Advancement in wireless networks crafts the access to the Internet from vehicles. The high-flying industries and governments such as Audi, BMW, Daimler-Chrysler, and Toyota have commenced important research for vehicle to vehicle communications. California Partners for Advanced Transit and Highways, Crash Avoidance Metrics Partnership, FleetNet, Advanced Driver Assistance Systems, Chauffeur in EU, CarTALK 2000, and DEMO 2000 are petty distinguished research, which are moving towards the realization of intellectual transport services.

With surging vehicle Internet services, VMesh network is facing unique opportunities and challenges. To coup the rapid development and demands due to the multimedia services, social networks, and entertainments, it is far from enough to only expand and upgrade current networks, which results in a substantial increase in CAPital EXPenditure (CAPEX) and OPERating EXPenditure (OPEX) without reasonable investment returns. Therefore, in order to offer a High-Quality of Experience (HQoE) for vehicle users with affordable costs, new network architecture is designed to enable sustainable network evolution to the 5G. Till now, much attention has been paid to emerging 5G technologies ranging from information processing to networking techniques. Most of the focus has been on further improving radio access efficiency through advanced signal

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processing, e.g., cooperative relaying, massive MIMO, and millimeter-wave communications [7–13]. On the other hand, the existing shaft-like network structure with centralized data processing is not suitable for flexible and diverse VANET Internet services, which undoubtedly restricts the service provisioning ability of the VMesh network. Hence, designing new network architecture becomes imperative. This motivates us to propose a new architecture for VMesh network with the integration of cloud and 5G technologies. However, there is still much work that needs to be done to improve the 5CVN architecture with good backward compatibility. This paper emphasizes how to maximize the utilization of resource without delay and congestion and to smoothly evolve towards converged 5CVN.

The motivations of the paper are as follows, nowadays, users of all ages want to share and get the information at anytime and anywhere via vehicle Internet service. Also, the growth of the Internet-of-Things (IoTs) has had serious effects in the VANET performance. It is expected that by the year 2020, average user data rates will increase from around 20 MB/s to 1 GB/s, and connection density will also increase from 140,000 connections per square kilometers to 6 million connections per square kilometers. Moreover, new applications such as the Internet-of-Vehicles are envisioned for 5G, which will demand much shorter latency from the underlying network. Considering the existing network infrastructure, telecommunication operators need to invest heavily on both network maintenance and upgrade to support ever increasing capacity requirements. However, revenues from increased data traffic cannot keep up with the investment. How to reduce CAPEX/OPEX and create new revenue flows are crucial issues facing telecommunication operators. The proposed 5CVN-adroit algorithm may perhaps solve the above issues.

In this paper, an integration of 5G-cloud-VMesh network is introduced. The envisioned architecture shall enable data access from the vehicles, anytime and anywhere. In particular, the integration of IEEE 802.11-based multi-hop VANETs with 5G shall contribute to the evolution of beyond 4G wireless communication systems. The proposed 5CVN-adroit algorithm addresses the choosing of an optimal gateway and Aggregator Node B (ANB) in the network layer from and to the service requesters and the cloud using 5G technologies. 5CVN-adroit algorithm consists of two key processes such as metric-based gateway selection and metric-based ANB selection. In the majority of the existing research, gateways are considered static and deployed on the road at fixed distances from each other, depending on their wireless transmission range, which makes the deployment costlier. Moreover, the multi-hop and dynamic nature of VANET communication impacts the stability of the links to these gateways. Furthermore, as these gateways are fixed, the discovery and routing

processes are mainly pro-active. Although the pro-active routing mechanisms reduce delay, they increase the frequent changes in the predefined routing tables of vehicles and routing overhead. To deal with these limitations, this paper defines the concept of vehicle gateways. Any vehicle in the VMesh network can act as a gateway. A gateway refers to the dual-interfaced vehicle that relays the packet from sources to the 5G backhaul network. It is enabled with dual interfaces of IEEE 802.11p and the 5G backhaul networks. The major challenge is to amalgamate these two network interfaces on a gateway, as they lie in two different spectrum regions. The next challenge is to choose a minimum number of optimal gateways using relevant metrics. There could be several nodes in the VMesh network, which possess the important criterion and required metric information, and hence, the qualification to serve as gateways. The focus of this paper is on defining a mechanism that chooses a minimum number of optimal gateways, at an instance, so as to avoid the bottleneck at the 5G backhaul network. With this regard, as pro-active gateway discovery reduces delay and reactive discovery reduces routing overhead, this paper envisages a hybrid gateway discovery mechanism for VMesh network, combining the pros of both pro-active and reactive concepts.

For example, network statistics show that 70 % of data traffic is carried by 30 % of base stations. To solve the above issue, we introduced ANB pool; a large number of ANBs can form an “ANB pool” with aggregated processing capabilities to serve the traffic requirements of the coverage area. For instance, there are certain regions with heavy traffic loads and certain ANB are overloaded. In such cases, ANB selection has been introduced to select the optimal ANB among the ANB pool. In the majority of the existing research, conventional centralized cloud is considered. However, the conventional centralized cloud may result in a high delay of offloading data delivery and in congestion of backhaul due to the transmission of the offloaded data. The perceived delay caused by the centralized cloud can be minimized by adopting a distributed cloud deployed over ANB of cellular network.

Our paper deals with the above-identified issues by the following key contributions such as:

- Our first goal is to propose a heterogeneous architecture combining IEEE 802.11p-based VMesh, cloud, and 5G. Furthermore, to make the vehicles prominently use the advantages of 5G to progress and expand their utility, we tested the proposed heterogeneous architecture under a realistic scenario where we consolidate real-world road topology generated by the microscopic mobility model provided by SUMO. We analyze 5CVN network topology characteristics over a

huge scale urban area using a real vehicle mobility model.

- Our second goal is to develop a new routing algorithm (5CVN-adroit algorithm). The 5CVN-adroit algorithm discovers an optimal gateway and ANB in order to route the service request from the service requester to the cloud. The main purpose of gateway selection in the 5CVN is to permit only a minimum number of vehicles to communicate with the ANB. Certainly, if all vehicles in a 5G VMesh network directly communicate with the ANB, it results in a bottleneck at the ANB. The rationale of ANB selection is to avoid the data traffic at the ANB.
- Our third goal is to analyze the performance of the proposed 5CVN-adroit algorithm over various performance metrics, including packet delivery ratio, average response time, routing overhead ratio, and packet collision ratio.

The rest of this article is organized as follows. In Section 2, we discuss the proposed 5CVN architecture and its main features. In Section 3, we describe the 5CVN-adroit algorithm. In Section 4, we discuss and analysis the performance of the 5CVN-adroit algorithm. Finally, in

Section 5, we present our conclusions and a description of future work that needs to be done.

### 2 Network architecture of 5CVN

To facilitate the flexible network control and reduce the network capital and operational expenditures, the complimentary concepts, 5G software-defined networking (SDN) components, and cloud have been integrated with VMesh networks. Through the proper cooperation between newly developed 5CVN and radio access network, vehicle user can enjoy a much better quality of experience with lower access delay and congestion. 5G SDN is fast evolving and becoming the focal point and a growth area in networking. 5G SDN is a new paradigm in networking, e.g., data and control plane separation, globally optimized network management, and centralized network controller [14–16].

Figure 1 illustrates the 5CVN network architecture. The 5CVN is heterogeneous and IP-based model with relays. The architecture includes a number of independent vehicles with the autonomous radio access technologies, ANB, MME, Serving Gateway (SG)/Gateway GPRS Support Node (GGSN), SDN controller, and cloud server. VMesh network user’s vehicle may have any technology provisions.

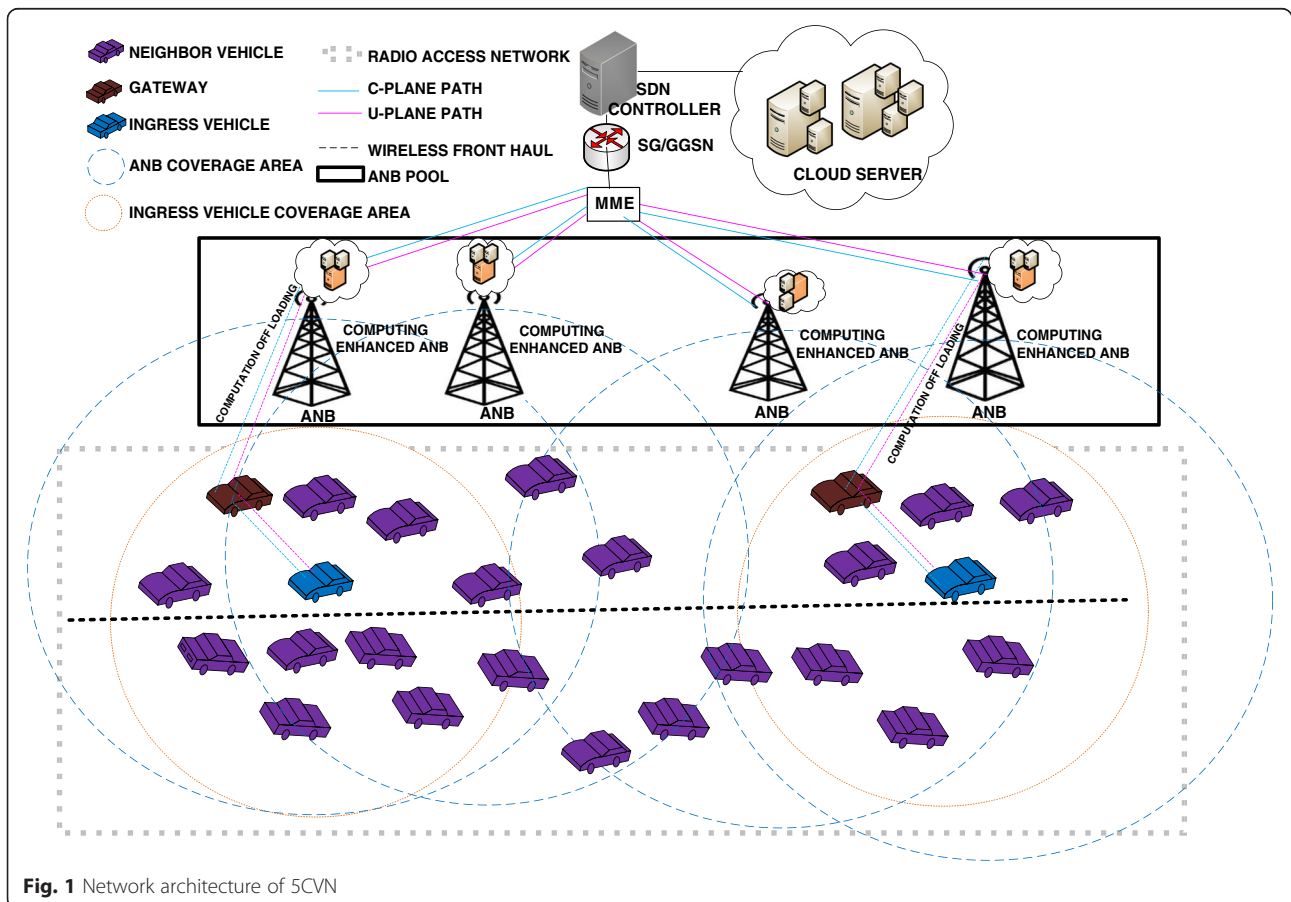


Fig. 1 Network architecture of 5CVN

ANB has local cloud and it also has a computing capability for offloading a computation from the vehicle. The local cloud consists of the service which the user opts often. ANB provides the air interface between the control plane protocol terminations and the user plane towards the autonomous Human Machine Interface (HMI). The interfaces of network are built on IP protocols. ANB is equipped with different MAC protocols to deliver different types of data information. The SG/GGSN act as a limited anchor for the mobility service for transmitting and receiving packet rates from and to the requester and cloud to serve the HMI request. Mobility Management Entity (MME) is an entity to afford signaling only, and later, the user packets of the IP do not pass over the MME. SDN controller allows administrators to manage network services through abstraction of lower-level functionality. A cloud server is a logical server that is built, hosted, and delivered through a cloud computing platform over the Internet. Cloud servers exhibit and possess similar capabilities and functionality to a usual server but are accessed remotely on-demand from a cloud service provider. The cloud server provides computation, data access, software, services, and storage that do not require service requester’s knowledge about the physical location and configuration of the system that deliver services.

As shown in Fig. 2. Service-level agreement (SLA) is the negotiation between the cloud server and service requesters for maintaining the QoS. Some metrics that SLAs may specify in the 5CVN are as follows:

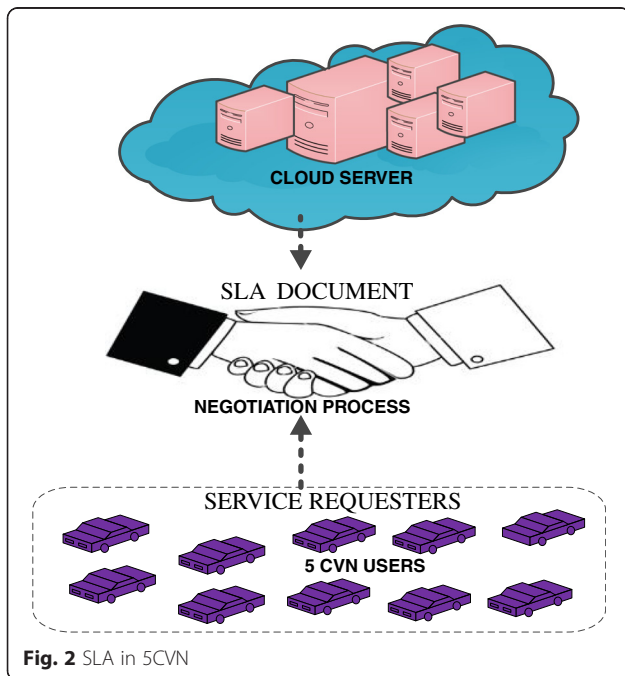


Fig. 2 SLA in 5CVN

- The number of 5CVN users that can be served simultaneously by the cloud.
- The particular performance benchmark to which actual performance to be compared periodically.
- Advance notification about the network changes.
- Help desk response time for different classes of problems and dial-in access accessibility.

### 3 5CVN-adroit algorithm

The 5CVN-adroit algorithm discovers an optimal gateway and ANB in the network layer to route the request/response from/to the requesters and the cloud using 5G technologies. An ingress vehicle (service requester vehicle) coverage area is IEEE 802.11p wireless transmission range. As expressed in Eq. 1, the coverage area of an ingress vehicle is determined as follows:

$$C_{area} = TR_{max}(1-\alpha) \tag{1}$$

where  $TR_{max}$  denotes the maximum IEEE 802.11p transmission range and  $\alpha$  reflects the wireless channel fading conditions of the ingress vehicle location. For instance,  $\alpha$  can be set to small values in environments when there are no major obstacles and takes high values in urban areas with tall buildings. A mapping function between the geographical locations and the values of  $\alpha$  can be provided by using position system such as GPS and Galileo. As illustrated in Algorithm 1, the 5CVN-adroit algorithm consists of two key processes such as metric-based gateway selection and metric-based ANB selection.

#### 3.1 Metric-based gateway selection

The ingress vehicle dynamically scans for the neighbor vehicle in the coverage area. Then, the ingress vehicle will send the beacon message to each neighbor vehicle and get the updated information periodically about the signal strength, number of packets in the buffer of the neighbor vehicle, and distance between ingress vehicle and neighbor vehicle. Based on the above periodic messages, the ingress vehicle calculates the fitness value for each neighbor vehicle, as given in Eq. 2. If an ingress vehicle does not receive reply beacon messages from the specific neighbor vehicle during a certain time period, then the link is considered down. The neighbor vehicle is discarded. The fitness value ( $fv$ ) for gateway selection (GS) is computed as follows:

$$fv(GS) = \frac{S_{str}}{NP * D_{t,i}} \quad \forall n, n = 1, 2, 3, \dots, r \tag{2}$$

where “ $fv(GS)$ ” is the fitness value for gateway selection, “ $S_{str}$ ” is the signal strength of the neighbor vehicle in terms of dBm, “ $Np$ ” is the number of packets in the buffer of the neighbor vehicle, “ $D_{t,i}$ ” is the distance between

the ingress vehicle and the neighbor vehicle in terms of meter, and “r” is the maximum number of the neighbor vehicles. Among all possible neighbor vehicles (NV)  $NV \in F \subset C_{area}$ , we want to determine a gateway ( $G_w$ ) that optimizes (maximum) the function fv:

$$G_w = \arg \max_{NV \in F \subset C_{area}} fv(GS) \tag{3}$$

where  $F$  is the feasible solution. As expressed in Eq. 3, among the neighbor vehicles, the vehicle which has the maximum fitness value is chosen as the gateway. The gateway activates its interface in order to communicate with the ANB. Then, the request from the ingress vehicle is transmitted to the gateway. The chosen gateway broadcasts periodic gateway advertisement (GWADV) messages within its coverage area up to time-to-live (TTL) value.

**3.1.1 Selecting on-hand gateway**

The new ingress vehicle checks for an on-hand (existing) gateway in its coverage area. If there is a gateway in its coverage area, then the new ingress vehicle will transmit the service request to an on-hand gateway and then go to the metric-based gateway selection.

**3.2 Metric-based ANB selection**

The range is distinct as the coverage area of the ANB. The ANB broadcasts periodic ANB advertisement (ANBADV) messages within its range (R). The gateway dynamically checks for the ANB to transmit the service request.

**3.2.1 Case 1**

If there is only one ANB, from the gateway, the service request is stanchly transmitted to the ANB.

**3.2.2 Case 2**

If there are no ANBs, the gateway dynamically scans for the neighbor vehicle towards its moving direction within its coverage area. Then, the gateway will send the beacon message to the each neighbor vehicle in the list. It gets the updated information periodically about the signal strength of the neighbor vehicle, number of packets in the buffer of the neighbor vehicle, and distance between the gateway and neighbor vehicle. Based on the above periodic messages, the gateway calculates the fitness value for each neighbor vehicle, as given in Eq. 4. If a gateway does not receive reply beacon messages from the specific neighbor vehicle during a certain time period, then the link is considered down. The neighbor vehicle is discarded. The fitness value (fv) for subsequent gateway selection (SGS) is computed as follows:

$$fv(SGS) = \frac{S_{str}}{NP * D_{q,e}} \quad \forall n, n = 1, 2, 3, \dots, s \tag{4}$$

where “fv(SGS)” is the fitness value for subsequent gateway selection, “ $S_{str}$ ” is the signal strength of the neighbor vehicle in terms of dBm, “Np” is the number of packets in the buffer of the neighbor vehicle, “ $D_{q,e}$ ” is the distance between the gateway and the neighbor vehicle in terms of meter, and “s” is the maximum number of the neighbor vehicles. Among all possible neighbor vehicles (NV)  $NV \in F \subset C_{area}$ , we want to determine a subsequent gateway ( $SG_w$ ) that optimizes (maximum) the function fv:

$$SG_w = \arg \max_{NV \in F \subset C_{area}} fv(SGS) \tag{5}$$

where  $F$  is the feasible solution. As expressed in Eq. 5, among the neighbor vehicles, the vehicle which has the maximum fitness value is chosen as the subsequent gateway. From the gateway, the service request is transmitted to the subsequent gateway and then goes to the metric-based ANB selection. Case 1 and case 2 are the worst cases.

**3.2.3 Case 3**

If there are two or more ANBs, the gateway will send the beacon message to each neighbor ANB, gets the up-to-the-minute information about the number of packets in the buffer of the ANB and the distance between the gateway and ANB, and calculates a fitness value for each ANB, as given in Eq. 6. If the gateway does not receive beacon messages from the specific neighbor ANB during a certain time period, then the link is considered down. The ANB is discarded. The fitness value (fv) for ANB selection (ANBS) is calculated as follows:

$$fv(ANBS) = NPB + D_{g,a} \quad \forall n, n = 1, 2, 3, \dots, w \tag{6}$$

where “fv(ANBS)” is the fitness value for ANB selection, “NPB” is the number of packets in the buffer of the ANB, “ $D_{g,a}$ ” is the distance between the gateway and ANB, and “w” is the maximum number of ANBs. Among all possible ANBs,  $ANB \in F \subset R$ , we want to determine an ANB that optimizes (minimum) the function fv:

$$OANB = \arg \min_{ANB \in FS \subset R} fv(ANBS) \tag{7}$$

where FS is the feasible solution. As expressed in Eq. 7, among the ANBs, the ANB, which has the minimum fitness value, is chosen as an optimal ANB (OANB). From the gateway, the request is transmitted to the optimal ANB.

The computing enhanced optimal ANB checks for the services in the local cloud as per the user requirement. If the service is found, the optimal ANB transmits the service to the requester. Else from the optimal ANB, the service request is transmitted to the cloud server via MME, SG/GGSN, and SDN controller. Service reply from the cloud server to the service requester follows the same request path.

<b>Algorithm 1: 5CVN-Adroit Algorithm</b>	
Source: Ingress Vehicle Destination: ANB or else Cloud Server Input: Service Request Output: Response from the ANB or cloud server Process: Route Discovery	
<p><b>5CVN Adroit Algorithm ()</b></p> <p><b>Begin Metrics based Gateway Selection</b>            The ingress vehicle scans for the neighbor vehicle in the coverage area.  <b>For</b> each NV <math>\leftarrow 1</math> to r <b>do</b>              Acquire <math>S_{str}, NP, D_{t,i}</math>              Calculate <math>f_v(GS) = \frac{S_{str}}{NP * D_{t,i}}</math>  <b>End For</b>  <math>G_w = \arg \max_{NV \in FI_{C_{area}}} f_v(GS)</math>            The request from an ingress vehicle is transmitted to the <math>G_w</math>.  <math>G_w</math> activates its interface in order to communicate with the ANB.  <b>Call Metrics based ANB Selection ();</b>  <b>End Metrics based Gateway Selection</b></p> <p><b>Begin Gateway Broadcast</b>  <math>G_w</math> broadcasts periodic GWADV within its coverage area for TTL value.  <b>End Gateway Broadcast</b></p> <p><b>Begin Selecting On-Hand Gateway</b>            The new ingress vehicle checks for an on-hand gateway in the coverage area.  <b>If</b> <math>G_w</math> is FOUND <b>then</b>              The new ingress vehicle will transmit the request to the on-hand gateway.              On-hand gateway activates its interface in order to communicate with the ANB.              <b>Call Metrics based ANB Selection ();</b>  <b>Else</b>              <b>Call Gateway Selection ();</b>  <b>End If</b>  <b>End Selecting On-Hand Gateway</b></p>	<p><b>Begin ANB Broadcast</b>            ANB broadcasts ANBADV messages within its range.  <b>End ANB Broadcast</b></p> <p><b>Metrics based ANB Selection</b>  <math>G_w</math> dynamically scans for the ANB  <b>If</b> (ANB=1) <b>then</b>              <math>G_w</math> transmits the request to the ANB  <b>Elseif</b> (ANB=0)              The gateway scans for the neighbor vehicle towards its moving direction in its coverage area.              <b>For</b> each NV <math>\leftarrow 1</math> to s <b>do</b>                Acquire <math>S_{str}, NP, D_{q,e}</math>                Calculate <math>f_v(SGS) = \frac{S_{str}}{NP * D_{q,e}}</math>  <b>End For</b>  <math>SG_w = \arg \max_{NV \in FI_{C_{area}}} f_v(SGS)</math>            The request from the gateway is transmitted to the <math>SG_w</math>.  <math>SG_w</math> activates its interface in order to communicate with the ANB.  <b>Call Metrics based ANB selection ();</b>  <b>Else</b>(ANB&gt;2)  <b>For</b> each ANB <math>\rightarrow 1</math> to w <b>do</b>              Acquire <math>NPB, D_{g,a}</math>;              Calculate <math>f_v(ANBS) = NPB + D_{g,a}</math>  <b>End For</b>  <math>OANB = \arg \min_{ANB \in FS1_R} f_v(ANBS)</math>            The request from the gateway is transmitted to the OANB.  <b>End If</b>  <b>End Metrics based ANB Selection</b></p> <p>The computing enhanced OANB check for the services in the local cloud as per the user requirement.  <b>If</b> service is FOUND <b>then</b>              OANB transmits the service to the requester.  <b>Else</b>              From the OANB the request is transmitted to the cloud server via MME, SG/GGSN and SDN controller.  <b>End If</b></p> <p>The service reply from the cloud server follows the same request-path.  <b>}</b></p>

#### 4 Simulation results and analysis

We implemented the 5CVN-adroit algorithm and the existing techniques on network simulator (NS2) and used the topology of the network generated by Simulation of Urban Mobility (SUMO). SUMO is the microscopic, open source, and multimodal traffic simulator. The simulation allows to address a large set of traffic management topics. Each vehicle is modeled explicitly and has an own route and travel independently through the network. Here, SUMO is coupled to a communication network simulator using a middleware (VSimRTI). The V2X Simulation Runtime Infrastructure (VSimRTI) is a framework which enables the groundwork and execution

of V2X simulations. The easier integration and exchange of simulators enables the replacement of the most relevant simulators for a realistic presentation of traffic, communication, and the execution of V2X applications. The NuoDB is a cloud database and offers a well-off SQL implementation and factual ACID transactions. Table 1 illustrates the characteristics of the environment in which the simulation is experimented. In the simulation, the request generation speeds remnants at five packets per second when the vehicle density changes.

In our existing work, we have proposed Optimized Heuristic Buffer-based Routing (OHBR) which focuses on proficient routing based on the buffer size and heuristic

**Table 1** Simulation parameters

Simulation parameters	Value
Network simulator	NS2
Traffic simulator	SUMO—0.15.0
Cloud server	NuoDB
Number of nodes	500
Number of ANB	18
MAC protocol	IEEE 802.11p
Real-time environment model	Rayleigh fading environment
Connection type	CBR or UDP
IP	IPV6
Packet size	64 kB
CBR interval	10 s
Nodes speed	20–160 km/h
Gateway broadcast timer	1 s
Antenna type	Antenna/omni directional antenna

fitness function, in order to reduce the packet loss, re-transmission, gridlock, protocol overhead, and delay in VMesh milieu [5]. In this work, we do not consider the base station selection which results in data traffic at the base station. The data traffic results in delay, packet loss, and packet collisions. Abderrahim et al. proposed a mechanism and named as Clustering-based Multi-metric adaptive mobile Gateway Management (CMGM) in which vehicles are dynamically clustered according to different related metrics such as UMTS received signal strength, direction of vehicles, and vehicle to vehicle distance [17]. However, the cluster mechanism leads to confusion in electing the cluster head. And as well in CMGM fixing, the gateway candidate progression is complex which results in a delay in gateway discovery mechanism. Kaouther et al. have proposed efficient and scalable LocVSDPs for VNs. The proposed protocols have vehicles provided with an efficient mechanism to locate service providers and how to reach them (routing) simultaneously [18]. However, in LocVSDPs for VNs, clustering leads to confusion in electing the cluster head and it will increase the routing overhead and delay. The performance of the proposed 5CVN-adroit algorithm and existing OHBR, 3G-CMGM, and LocVSDPs are assessed in terms of the packet delivery ratio, average response time, routing overhead ratio, and packet collision ratio. The intricate descriptions of these indexes are as follows:

*Packet Delivery Ratio (PDR)*: PDR is defined as the ratio between the number of responses received by the source to the number of requests sent.

*Average Response Time (ART)*: ART is the average difference between the time a request packet is

originated by an application and the time the response packet is received.

*Routing Overhead Ratio (ROR)*: ROR is defined as the ratio between the total number of bytes of control packets and the cumulative size of data packets which are delivered to the destinations to the total number of control packets and the cumulative size of data packets sent.

*Packet Collision Ratio (PCR)*: The packet collision ratio is defined as the number of packets collided to the number of packets transmitted. This gives an indication of the loading of the network.

Table 2 depicts the simulation results obtained by the proposed 5CVN-adroit algorithm (A), existing OHBR (O), 3G-CMGM (C), and LocVSDPs (L) for different request generation speed (RGS) and vehicle density (VD). Based on the obtained results, we calculate the PDR, ART, RO, and PCR. In our existing work Optimized Heuristic Buffer-based Routing (OHBR), we do not consider the base station pool and the base station selection which results in data traffic at the base station when the RGS and VD rises. This results in delay, packet loss, and packet collisions. Consequently, PDR and RO decrease, and ART and PCR increase. In existing 3G-CMGM, the cluster mechanism leads to confusion in electing the cluster head. It results in a decrease in the PDR and RO and increase in the ART and PCR. In addition, in CMGM fixing, the gateway candidate progression is complex which results in a delay in gateway discovery mechanism. The existing LocVSDPs relies on roadside routers. The roadside router has to be planned and deployed on the road side. Consequently, the deployment cost is high. LocVSDPs is also the cluster-based approach. The cluster creates confusion in the routing process, results in the diminishing of the PDR and RO, and rises in the ART and PCR. However, in the proposed mechanism by using the 5G technology components, adroit algorithm, and local cloud at ANB, the VMesh user can enjoy with the minimum delay and maximum delivery ratio.

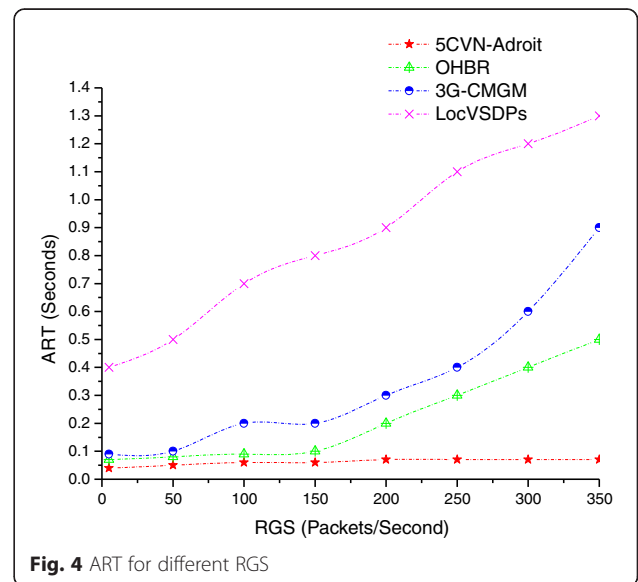
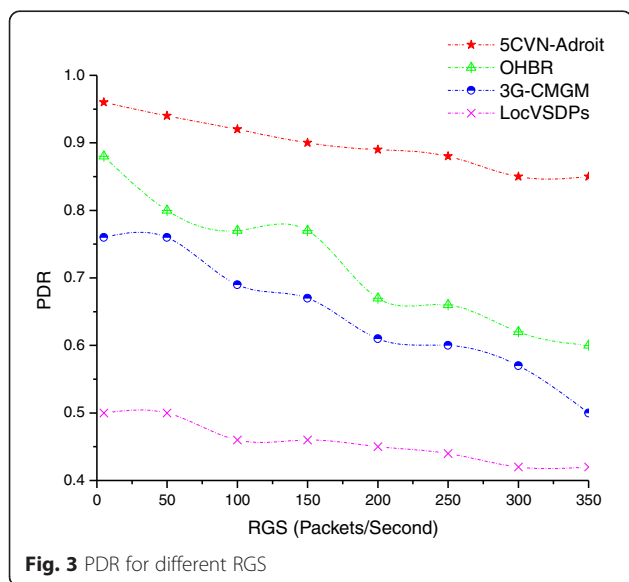
The impact of various RGS on PDR is illustrated in Fig. 3. It can be deduced from this figure that PDR decreases as the RGS rises. Higher RGS causes more network topology changes and more link failures and thereby PDR decreases accordingly. Owing to the introduction of gateway and ANB selection based on the relevant metrics, the probability of disconnections between platoons shows an improvement in the 5CVN-adroit algorithm over to the OHBR, 3G-CMGM, and LocVSDPs. Hence, the PDR of the 5CVN-adroit algorithm outperforms the existing techniques. As depicted in Fig. 4, the ART of OHBR, 3G-CMGM, LocVSDPs, and 5CVN-adroit algorithm increases when the number of request increases. Higher RGS generates more network topology changes and more delay. In

**Table 2** Simulation results

RGS	PDR				ART				RO				PCR			
	A	O	C	L	A	O	C	L	A	O	C	L	A	O	C	L
5	0.96	0.88	0.76	0.5	0.04	0.07	0.09	0.4	100	92	80	50	0.02	0.1	0.3	0.5
50	0.94	0.8	0.76	0.5	0.05	0.08	0.1	0.5	94	80	76	50	0.02	0.1	0.32	0.58
100	0.92	0.77	0.69	0.46	0.06	0.09	0.2	0.7	92	77	69	46	0.02	0.1	0.36	0.6
150	0.9	0.77	0.67	0.46	0.06	0.1	0.2	0.8	90	77	67	46	0.02	0.12	0.37	0.6
200	0.89	0.67	0.61	0.45	0.07	0.2	0.3	0.9	89	67	65	45	0.024	0.12	0.4	0.62
250	0.88	0.66	0.6	0.44	0.07	0.3	0.4	1.1	88	66	60	44	0.026	0.13	0.4	0.7
300	0.85	0.62	0.57	0.42	0.07	0.4	0.6	1.2	85	62	57	42	0.028	0.17	0.4	0.8
350	0.85	0.6	0.5	0.42	0.07	0.5	0.9	1.3	80	55	45	42	0.035	0.17	0.45	0.85
VD	PDR				ART				RO				PCR			
	A	O	C	L	A	O	C	L	A	O	C	L	A	O	C	L
25	0.96	0.88	0.72	0.6	0.02	0.05	0.06	0.1	100	88	72	60	0.01	0.03	0.04	0.1
250	0.92	0.86	0.7	0.6	0.03	0.06	0.07	0.15	96	86	70	60	0.01	0.034	0.062	0.1
500	0.92	0.82	0.7	0.6	0.05	0.07	0.08	0.2	96	82	70	60	0.01	0.035	0.07	0.1
750	0.92	0.81	0.56	0.53	0.06	0.08	0.1	0.25	95	81	65	53	0.02	0.036	0.075	0.12
1000	0.91	0.81	0.45	0.42	0.06	0.08	0.2	0.3	95	81	60	42	0.02	0.038	0.08	0.13
1250	0.8	0.72	0.44	0.32	0.068	0.09	0.3	0.35	90	72	55	32	0.02	0.039	0.088	0.13
1500	0.8	0.6	0.4	0.3	0.08	0.1	0.4	0.45	90	72	50	30	0.02	0.04	0.093	0.14
1750	0.8	0.6	0.4	0.3	0.08	0.2	0.5	0.6	90	72	50	30	0.03	0.044	0.095	0.15

existing techniques, the selected gateways and the base station will be overloaded with packets, some of which will be left over, finally impacting the packet loss and retransmission, which will increase the response time. In the 5CVN-adroit algorithm, as the gateway and the ANB are chosen based on the minimum number of packets in the buffer, it will decrease the processing delay. In addition, in the 5CVN-adroit algorithm, the next-hop gateway and the

ANB are picked based on the fitness value and reserved ahead before ingress vehicle transmitting the request. As a consequence, the ART of the 5CVN-adroit algorithm outperforms the ART of OHBR, 3G-CMGM and LocVSDPs. Accordingly, we have compared the ROR performance of the 5CVN-adroit algorithm, OHBR, 3G-CMGM, and LocVSDPs with RGS varying in Fig. 5. It can be figured out from this figure that ROR decreases as the RGS rises.





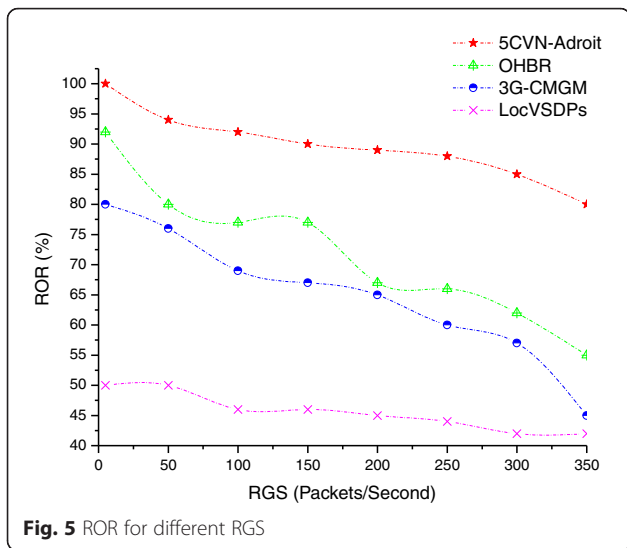


Fig. 5 ROR for different RGS

By virtue of gateway selection, the 5CVN-adroit algorithm is more likely to find a route from source to destination without any confusion in the routing process. Thus, the 5CVN-adroit algorithm outperforms the ROR of OHBR, 3G-CMGM, and LocVSDPs in terms of higher routing overhead ratio. It can be deduced from Fig. 6 that PCR of OHBR, 3G-CMGM, LocVSDPs, and 5CVN-adroit algorithm increases as the RGS increases. This result is rational and illustrates that high data rate may easily inundate the service channel of IEEE 802.11p since no differentiated service is being used. Compared to OHBR, 3G-CMGM, and LocVSDPs, the 5CVN-adroit algorithm shows the superlative PCR owing to its routing selection concern which combines the delay estimation and path connectivity together.

The influence of vehicle density on PDR of the 5CVN-adroit algorithm, OHBR, 3G-CMGM, and LocVSDPs is

plotted in Fig. 7. It is worth stressing that the impact of vehicle density on PDR is more apparent than that of RGS. The PDR of OHBR, 3G-CMGM, LocVSDPs, and 5CVN-adroit algorithm generally shows a diminishing trend in the growth of vehicle density. However, a large vehicle density will introduce more collisions and retransmissions on the IEEE 802.11p MAC layer. Thus, the OHBR, 3G-CMGM, LocVSDPs, and 5CVN-adroit algorithm experience a dropping PDR when vehicle density increases. Due to the usage of real connected paths in 5CVN-adroit algorithm between source and destination, it can easily tolerate MAC collisions, thus still providing better PDR when vehicle density is more. From Fig. 8, it can be deduced that with the continuous increase of vehicle density, the ART of OHBR, 3G-CMGM, LocVSDPs, and 5CVN-adroit algorithm also increases. Higher density generates more network topology changes and more delay. By selecting the qualified gateway and ANB based on relevant metrics, ART of adroit algorithm outperforms the ART of existing techniques. In addition, by using the local cloud in computing enhanced ANB, the ART of 5CVN-adroit algorithm outperforms the existing techniques. As shown in Fig. 9, the ROR of the 5CVN-adroit algorithm, OHBR, 3G-CMGM, and LocVSDPs decreases when the vehicle density increases. The existing techniques create confusions in the routing process; hence, it will decrease the routing overhead ratio. To avoid the confusion in adroit algorithm, quantified gateway and ANB has been selected. In addition, the next-hop gateway and ANB is picked and reserved ahead; that causes less routing overhead. Therefore, the ROR of the proposed scheme is high compared to the existing techniques. The 5CVN-adroit algorithm has some advantage in the aspects of ROR by considering important path selection factors such as link availability and link quality,

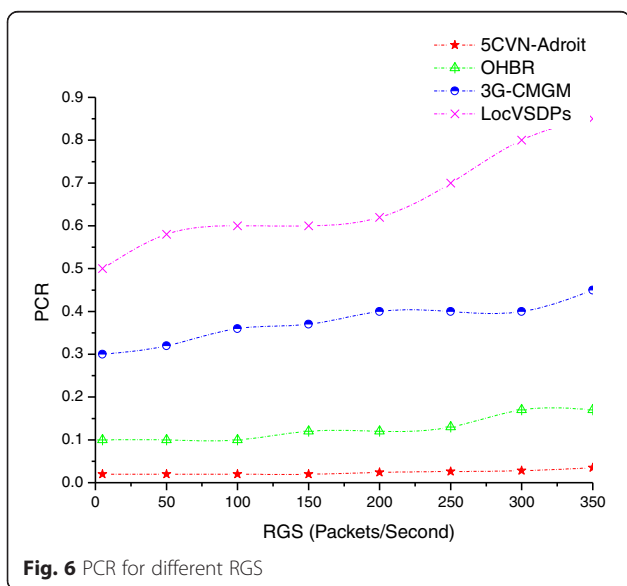


Fig. 6 PCR for different RGS

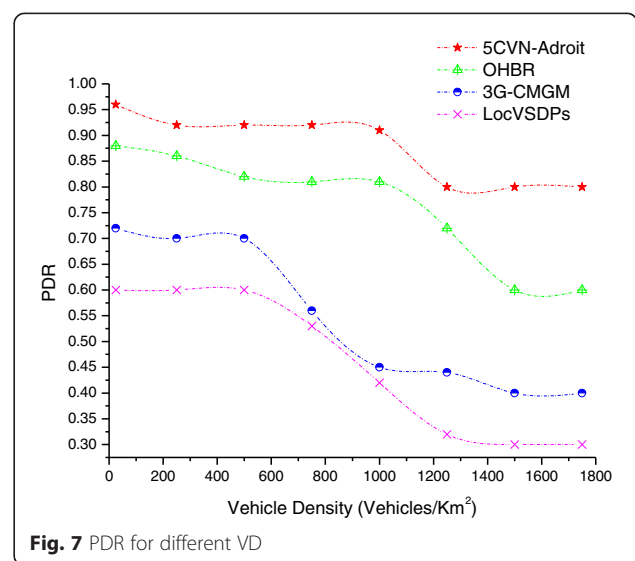
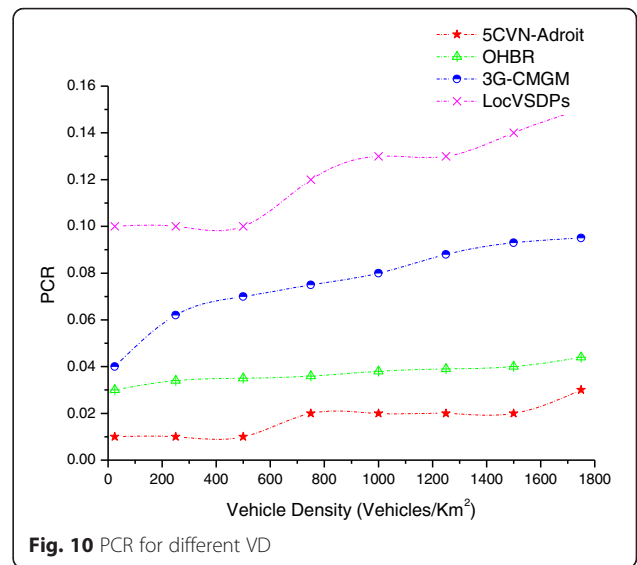
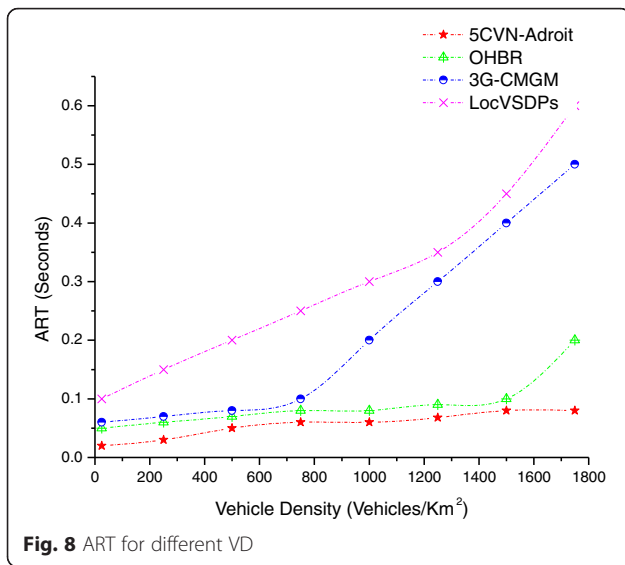


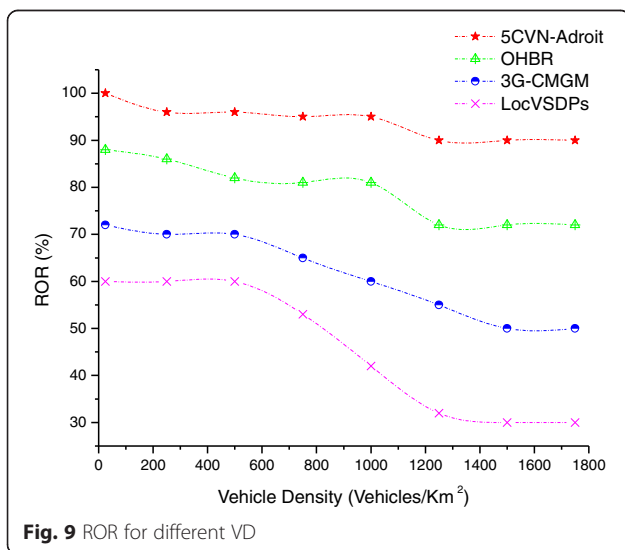
Fig. 7 PDR for different VD



which is of great importance to select a better route. Thus, the 5CVN-adroit algorithm shows better reliability and scalability. PCR is affected by different parameters such as vehicle density and traffic load. The results presented in Fig. 10 suggest that the proposed 5CVN-adroit algorithm is not affected as much as existing techniques. The increase in vehicle density brings more collisions on MAC. The reason behind is that more retransmission and collision causes the routing layer to use more beacons. The 5CVN-adroit algorithm reduces the retransmission and collision by introducing an ANB selection mechanism among an ANB pool. Thus, the PCR of adroit algorithm outperforms the existing techniques.

### 5 Conclusions

The proposed 5CVN-adroit algorithm affords high performance, globally optimized load balancing and network usage increased from 30 % to over 90 %. In this paper, we initiate an architecture that amalgamates 5G SDN, cloud, and VMesh networks, which offers advanced network services and apps at software speed for the users. The simulation results show that our 5CVN-adroit algorithm is very suitable for real-time applications and outperforms the existing techniques on packet delivery ratio, average response time, routing overhead ratio, and packet collision ratio. However, there is still much research needed to fully exploit the potential of 5CVN. This paper may be giving a good platform to motivate the researchers for a better outcome of different types of problems in next generation networks.



### Competing interests

The authors declare that they have no competing interests.

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Received: 26 January 2016 Accepted: 13 March 2016

Published online: 31 March 2016

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